

ARCHEAN SEDIMENTARY STYLES AND EARLY CRUSTAL EVOLUTION; Donald R. Lowe, Department of Geology, Louisiana State University, Baton Rouge, LA 70803

Preserved Archean sedimentary rocks accumulated in at least three major depositional settings represented by sedimentary units (I) in early, pre-3.0 Ga-old greenstone belts, (II) on late Archean cratons formed from the early Archean greenstone belts, and (III) in late Archean, post-3.0 Ga-old greenstone belts.

(I) The principal volcanic sequences of early Archean greenstone belts in the Barberton Mountain Land, South Africa, and the eastern Pilbara Block, Western Australia, contain sedimentary units deposited on low-relief, anorogenic but rapidly subsiding, shallow-water platforms constructed largely of mafic and ultramafic volcanic rocks (1). The primary sediment types included fresh or only slightly reworked pyroclastic debris; orthochemical precipitates including carbonate, evaporites, and silica; and biogenic deposits now represented by black carbonaceous chert, banded chert, and stromatolitic units (1, 2, 3). Terrigenous deposits, such as sandstone and shale derived by weathering and erosion of older rocks, are rare. Algoma-type iron formation, volcanogenic massive sulfide deposits, and turbidites, all of which usually form under deeper-water conditions, are also poorly developed. Detrital modes of clastic units are dominated by volcanic and intraformational sedimentary components and essentially lack coarse alpha-quartz, potash feldspar, and metamorphic and plutonic rock fragments. These units reflect sedimentation on large, shallow-water simatic platforms far removed from sources of sialic detritus.

The upper, sedimentary parts of these early Archean greenstone belt sequences are made up largely of detrital units reflecting orogenesis and deep erosion (4). The debris includes material eroded from both the underlying greenstone belt sequence and quartzose intrusive and metamorphic rocks. Deposition took place in environments ranging from alluvial to deep-sea (4). These units mark the regional transition from simatic platforms to continents.

(II) Following early Archean cratonization, the South African Kaapvaal and Australian Pilbara cratons were subject to deep erosion and, in late Archean time, were the sites of deposition of thick sedimentary and volcanic sequences. These include the Fortescue Group on the Pilbara Block and the Pongola and Witwatersrand Supergroups and succeeding units in South Africa. Although volcanism was widespread during the accumulation of many of these sequences, the sedimentary rocks clearly reflect deposition on relatively stable blocks of continental crust. They directly overlie the eroded plutonic and greenstone belt basement of early Archean age, are much less deformed and metamorphosed than underlying greenstone belt rocks, have not been extensively intruded by granitoid plutonic rocks, and contain large amounts of craton-derived arkosic and quartzitic debris.

(III) Late Archean, post-3.0 Ga greenstone belts in Canada and much of the Yilgarn Block, Western Australia, include sedimentary units in the volcanic part of the sequence that differ significantly from those in the older belts (1). Coarse terrigenous clastic units occur throughout the volcanic section instead of just at the top, as in older belts. These units are made up of conglomerate, sandstone, and shale derived largely by erosion of the greenstone belt sequence itself but contain detritus eroded from penecontemporaneous intrusions and older sialic basement. Deposition was mainly by subaqueous sediment gravity flows, including turbidity currents and debris flows. Shallow-water deposits in the volcanic sections accumulated mainly around high-standing felsic volcanic cones. Carbonaceous cherts, banded cherts, and evaporites are rare, whereas volcanogenic sulfide deposits and Algoma-type

iron formation are widespread. Deposition took place under subaqueous, in large part deep-water, tectonically unstable conditions (1).

As in the older belts, the uppermost clastic units at the top of the greenstone belt sequence reflect orogenesis. They were deposited in an association of environments ranging from alluvial to deep-sea (5).

The sedimentology of these Archean sedimentary systems bears strongly on interpretations of the character and evolution of the Archean crust. (A) The preserved early Archean greenstone belts formed as large, high-standing, anorogenic simatic blocks that were not underlain by or adjacent to significantly older continental crust. They underwent cratonization which age relationships of associated plutonic rocks suggest proceeded more-or-less concurrently with deposition of the greenstone belt sequences (6, 7).

(B) The cratons formed from these early Archean greenstone belts served as sites for the deposition of late Archean volcanic and shallow-water shelf sequences. These deposits are generally similar to cratonic sediments that are abundant in younger sequences and are clearly distinct from greenstone belt sediments.

(C) In contrast to the early Archean belts, late Archean greenstone belts represent largely subaqueous and tectonically active depositional sites (1). Both radiometric dating and included detrital sediments indicate that they formed in close association with significantly older sialic blocks. These belts also underwent cratonization more-or-less concurrently with accumulation of the greenstone belt sequences to form stable continental blocks that hosted the subsequent deposition of early Proterozoic shelf sediments. The co-existence in the late Archean of (a) large, stable cratons in South Africa and the Pilbara, Western Australia, and (b) younger greenstone belts in Canada, the Yilgarn, and elsewhere emphasizes the clear sedimentological and tectonic contrasts between these terranes. These contrasts argue strongly against suggestions that greenstone belts developed upon blocks of continental crust.

These results suggest that the Archean was characterized by at least two diachronous styles of crustal evolution. Early Archean cratons evolved from anorogenic shallow-water simatic platforms, perhaps resembling modern oceanic islands formed over hot spots. These platforms show no evidence of an association with significantly older continental blocks. Late Archean greenstone belts, perhaps analogous to modern magmatic arcs, developed adjacent to but not entirely upon older sialic blocks.

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